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⑭発明の名称　望遠対物レンズ

⑳特　願　昭61－102780
㉒出　願　昭61(1986)5月2日
優先権主張　㉜昭60(1985)6月29日㉝日本(JP)㉛特願　昭60－144167

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明　細　書

1．発明の名称

望遠対物レンズ

2．特許請求の範囲

物対側より共に正のパワーをもつ第1、第2レンズ群より構成され、第1レンズ群は、1枚の正レンズと1枚の負レンズとからなり、第2レンズ群は物対側に凸面を向けたメニスカス正レンズと物対側に凸面を向けたメニスカス負レンズとからなり、且つ下記の各条件を満足して構成したことを特徴とする、望遠対物レンズ。

(1) $1.0 < f_1 / f < 3.0$

(2) $0.2 < d_4 / f < 0.7$

(3) $0.1 < |r_2| / f_1 < 0.7$

(4) $1.0 < r_7 / r_8 < 2.0$

(5) $\nu_{1+} > 65$ ，　$\nu_{1+} - \nu_{1-} > 25$

(6) $d_6 / f < 0.15$

(7) $10 < \nu_{2+} - \nu_{2-} < 50$

ただし

f：全系の焦点距離

f_1：第1レンズ群の焦点距離

d_i：物体側より第i番目の面と第$(i+1)$番目の面との間隔

r_i：物対側より第i番目の面の曲率半径

ν_{1+}：第1レンズ群中の正レンズのアッベ数

ν_{1-}：第1レンズ群中の負レンズのアッベ数

ν_{2+}：第2レンズ群中の正レンズのアッベ数

ν_{2-}：第2レンズ群中の負レンズのアッベ数

3．発明の詳細な説明

a．技術分野

本発明は、天体写真撮影などに用いられる、簡単な構成で、しかも口径比1：4前後の大口径望遠対物レンズに関するものである。

b．従来技術及びその問題点

従来、天体写真撮影に用いられる光学系には、シュミット光学系を用いた反射型望遠レンズ、一般写真用超望遠レンズ、あるいは短焦点天体望遠鏡用対物レンズなどが用いられてきた。

シュミット光学系のような反射型望遠レンズは、比較的大口径のものが得られるが、非球面加工が

困難であり、量産化が難かしく、高価であるのに加え、光学系の調整が難かしく、手軽に良質の像を得にくいという問題がある。

また、近年よく見られるようになった、特殊低分散硝子を用いた、一般写真用高性能超望遠レンズを用いることも考えられるが、これらのレンズは、天体撮影には適するものの、構成枚数も多く、内焦機構や絞り機構を有し、非常に高価である。

従って、短焦点の天体望遠鏡対物レンズが天体撮影レンズとしてよく用いられる。しかしながら、天体望遠鏡は従来、色収差，球面収差，コマ収差を十分小さくする必要があり、例えば特開昭５９－２２０７１１号公報に開示される如く、口径比1：７前後が限度であり、天体写真撮影用としてはやや暗く、追尾用大型赤道儀が必要であるため、より大口径，広画角のものが望まれてきた。

c．目的

本発明は、以上のような点に鑑みなされたもので、大口径でありながら、構成枚数が少なく、低価格の大口径，広画角の望遠対物レンズを得ることを目的とする。

d．発明の構成

本発明の望遠対物レンズは、前述の目的を達成するために、物体側より共に正のパワーを持つ第１、第２レンズ群より構成され、第１レンズ群は１枚の正レンズと１枚の負レンズとからなり、第２レンズ群は物体側に凸面を向けたメニスカス正レンズと物体側に凸面を向けたメニスカス負レンズとからなり、更に次の諸条件を満足するように構成される。

(1) $1.0 < f_1 / f < 3.0$

(2) $0.2 < d_4 / f < 0.7$

(3) $0.1 < |r_2| / f_1 < 0.7$

(4) $1.0 < r_7 / r_8 < 2.0$

(5) $\nu_{1+} > 65$ ，　$\nu_{1+} - \nu_{1-} > 25$

(6) $d_8 / f < 0.15$

(7) $10 < \nu_{2+} - \nu_{2-} < 50$

ただし

f：全系の焦点距離

f_1：第１レンズ群の焦点距離

d_i：物対側より第i番目の面と第$(i+1)$番目の面との間隔

r_i：物体側より第i番目の面の曲率半径

ν_{1+}：第１レンズ群中の正レンズのアッベ数

ν_{1-}：第１レンズ群中の負レンズのアッベ数

ν_{2+}：第２レンズ群中の正レンズのアッベ数

ν_{2-}：第２レンズ群中の負レンズのアッベ数

e．作用

次に各条件について説明する。

条件(1)は第１レンズ群の焦点距離についてのものである。条件(1)の下限を超えると、第１レンズ群のパワーが過大となり、各面の曲率半径が小さくなり、球面収差を小さくおさえることが困難になる。逆に上限を超えると、第２レンズ群にかかる負担が大きくなり過ぎると共に、望遠比が大きくなり、レンズ全長を短かくおさえることが困難になり好ましくない。

条件(2)は第１レンズ群と第２レンズ群の空気間隔についてのものである。条件(2)の下限を超えて、第２レンズ群が第１レンズ群に近ずくと、基本的にダブレット構成からなる第１レンズ群によって発生する像面湾曲を、第２レンズ群で良好に補正することが困難になる。また、第２レンズ群のレンズ径が大きくなり、コスト高にもなる。逆に、条件(2)の上限を超えると、バックフォーカスが短かくなり、カメラ等の取り付けに問題を生ずる。

条件(3)は第１レンズ群中における球面収差，コマ収差を良好に補正するための条件である。条件(3)の下限を超えると、球面収差，コマ収差を補正するために、第３面も第２面に付随して曲率半径を小さくすることが必要となり、高次の球面収差が発生しやすくなる。逆に上限を超えると、球面収差の補正は容易になるが、２次スペクトルの色収差を小さくおさえることが困難になる。

条件(4)は第２レンズ群中の負レンズの曲率半径についてのものである。条件(4)の下限を超えると、ペッツバール和を小さくおさえることが困難になり、また像面湾曲が補正不足になる。逆に上限を超えると、負のペッツバール和が増大し、

好ましくない。

条件(5)は球面収差と色収差をバランスよく補正するための条件である。条件(5)で第１レンズ群中の正レンズのアッベ数を６５以上に保つことにより、第１レンズ群中で発生する２次スペクトルの色収差を小さくおさえることが可能である。さらに第１レンズ群中の正レンズと負レンズのアッベ数の差を２５以上に保つことにより、色収差補正の条件を満足するために各レンズのパワーを分散し、高次の球面収差の発生をおさえることが可能である。

条件(6)は第２レンズ群中の正レンズと負レンズとの空気間隔についてのものである。条件(6)の上限を超えると、第１レンズ群のパワーを分散し高次の球面収差の発生をおさえることは可能であるが、第１レンズ群で良好に補正された色収差を、第２レンズ群で大きく変化させることなく、像面湾曲を補正することが困難になる。

条件(7)は第２レンズ群中において発生する色収差を小さくするための条件である。本発明では、第１レンズ群で主に２次スペクトルの色収差を小さくおさえることを特徴とするが、第２レンズ群中の正レンズと負レンズのアッベ数の差を１０から５０に保つことにより、第１レンズ群で良好に補正された色収差を大きくかえることなく、球面収差，像面湾曲を補正することが可能である。

ｆ．実施例

以下に本発明実施例の数値データを示す。ただし、ｆは焦点距離，F_{NO}は口径比，ωは半画角，ｒはレンズ各面の曲率半径，ｄは第ｉ面と第(ｉ＋１)面との間隔、ｎは各レンズのｄ線の屈折率，νは各レンズのアッベ数である。

〔実施例　１〕

ｆ＝100.0　　F_{NO}＝１：４.０　　ω＝５.０°

面No	ｒ	ｄ	ｎ	ν
1	51.005	1.750	1.61340	43.8
2	26.700	0.300		
3	26.694	4.500	1.49700	81.6
4	475.283	43.089		
5	22.296	2.250	1.58913	61.0
6	50.458	2.705		
7	23.941	5.500	1.72342	37.9
8	13.899			

$f_1 = 1.48f$　　$d_4 = 0.43f$

$|r_2| = 0.18f_1$　　$r_7/r_8 = 1.72$

$\nu_{1+} = 81.6$　　$\nu_{1+} - \nu_{1-} = 37.8$

$d_8 = 0.03f$　　$\nu_{II+} - \nu_{II-} = 23.1$

〔実施例　２〕

ｆ＝100.0　　F_{NO}＝１：４.０　　ω＝５.０°

面No	ｒ	ｄ	ｎ	ν
1	51.264	4.501	1.49700	81.6
2	−51.264	0.755		
3	−49.799	1.750	1.58144	40.8
4	−2125.590	37.285		
5	24.232	2.251	1.56883	56.3
6	35.434	3.333		
7	20.466	5.502	1.62004	36.3
8	13.856			

$f_1 = 1.22f$　　$d_4 = 0.37f$

$|r_2| = 0.42f_1$　　$r_7/r_8 = 1.48$

$\nu_{1+} = 81.6$　　$\nu_{1+} - \nu_{1-} = 40.8$

$d_8 = 0.03f$　　$\nu_{II+} - \nu_{II-} = 20.0$

〔実施例　3〕

$f=100.0$　$F_{NO}=1:4.0$　$\omega=5.0°$

面No	r	d	n	ν
1	76.453	3.750	1.48749	70.1
2	−93.796	1.250		
3	−89.967	1.750	1.80518	25.4
4	−267.477	38.808		
5	29.009	2.250	1.65160	58.5
6	53.458	10.982		
7	19.938	5.000	1.80518	25.4
8	14.046			

$f_1=1.75f$　$d_4=0.39f$

$|r_2|=0.54f_1$　$r_7/r_8=1.42$

$\nu_{1+}=70.1$　$\nu_{1+}-\nu_{1-}=44.7$

$d_6=0.11f$　$\nu_{II+}-\nu_{II-}=33.1$

〔実施例　4〕

$f=100.0$　$F_{NO}=1:4.0$　$\omega=5.0°$

面No	r	d	n	ν
1	57.456	4.800	1.49700	81.6
2	−44.211	0.961		
3	−41.983	2.000	1.52944	51.7
4	142.685	32.498		
5	24.973	2.776	1.49700	81.6
6	78.233	1.073		
7	21.148	6.000	1.74950	35.3
8	14.298			

$f_1=2.47f$　$d_4=0.32f$

$|r_2|=0.18f_1$　$r_7/r_8=1.48$

$\nu_{1+}=81.6$　$\nu_{1+}-\nu_{1-}=29.9$

$d_6=0.011f$　$\nu_{II+}-\nu_{II-}=46.3$

〔実施例　5〕

$f=100.0$　$F_{NO}=1:4.0$　$\omega=5.0°$

面No	r	d	n	ν
1	54.309	4.800	1.49700	81.6
2	−36.414	0.441		
3	−35.414	2.000	1.54072	47.2
4	1106.305	29.999		
5	17.775	2.325	1.70154	41.2
6	28.457	0.250		
7	20.510	3.750	1.71736	29.5
8	12.621			

$f_1=1.35f$　$d_4=0.30f$

$|r_2|=0.27f_1$　$r_7/r_8=1.63$

$\nu_{1+}=81.6$　$\nu_{1+}-\nu_{1-}=34.4$

$d_6=0.003f$　$\nu_{II+}-\nu_{II-}=11.7$

g．効果

以上説明したように本発明は、正・負・正・負または負・正・正・負のレンズ構成よりなり、前記各条件を満足して構成したことにより、特開昭59−220711号公報に開示された収差図と本発明の実施例1，2，3，4，5の収差図とを比較すればわかるように、上記特開昭59−220711号公報の発明が口径比1：6.7，半画角2.5°であるのに対し、本発明では口径比1：4，半画角5°と大口径，広画角化を達成しているにもかかわらず、構成枚数も4枚と少なく、安価でしかも十分収差の小さい大口径，広画角の望超対物レンズを得ることができる。

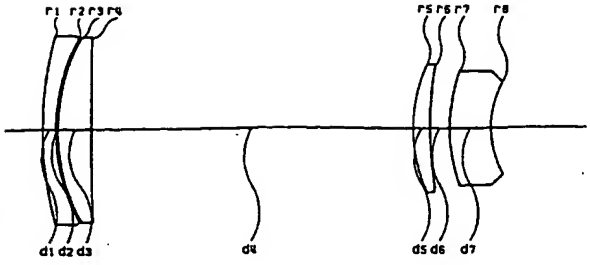
ヶ．図面の簡単な説明

第1図は本発明の実施例1のレンズ断面図，第2図は本発明の実施例1の諸収差図，第3図は本発明の実施例2のレンズ断面図，第4図は本発明の実施例2の諸収差図，第5図は本発明の実施例3のレンズ断面図，第6図は本発明の実施例3の諸収差図、第7図は本発明の実施例4のレンズ断

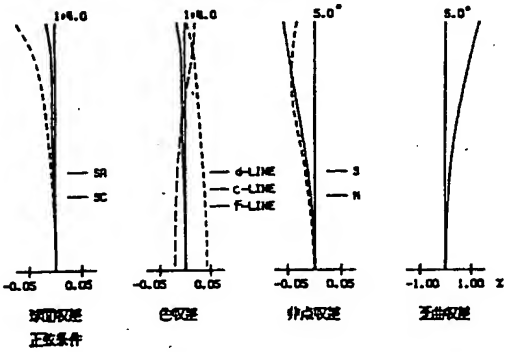
面図、第8図は本発明の実施例4の諸収差図、第9図は本発明の実施例5のレンズ断面図、第10図は本発明の実施例5の諸収差図である。

特許出願人　旭光学工業株式会社
代表者　松本　徹
同代理人　弁理士　伊丹辰男

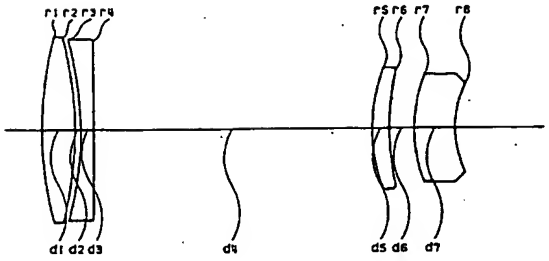
第1図



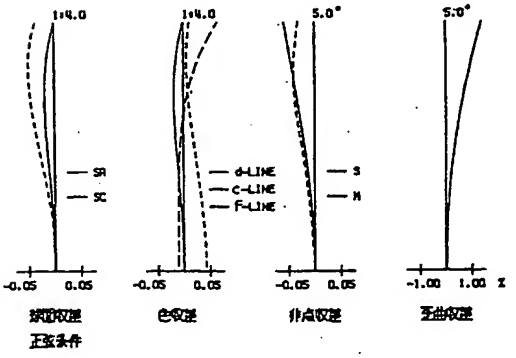
第2図



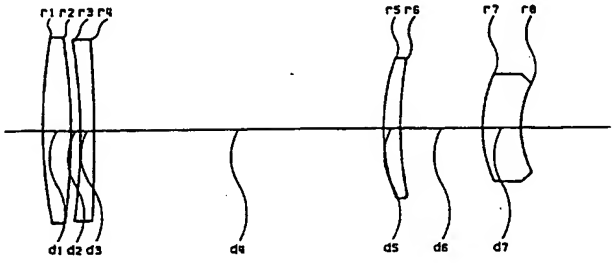
第3図



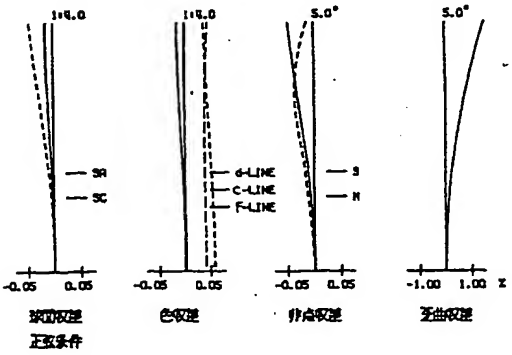
第4図



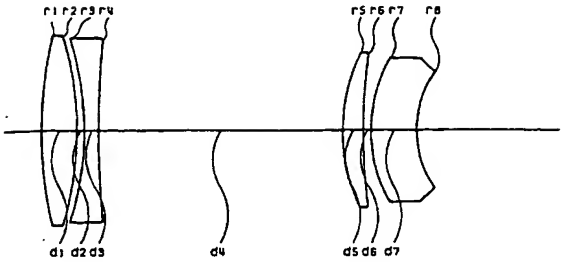
第5図



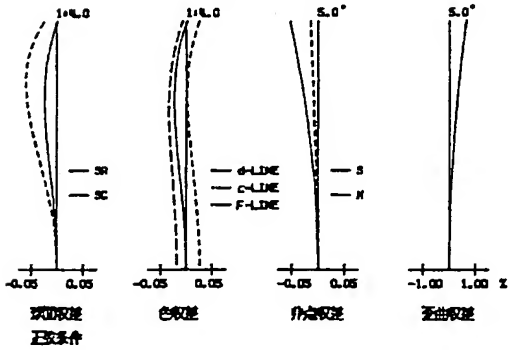
第6図



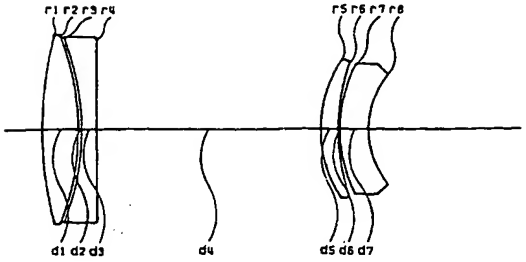
第 7 図



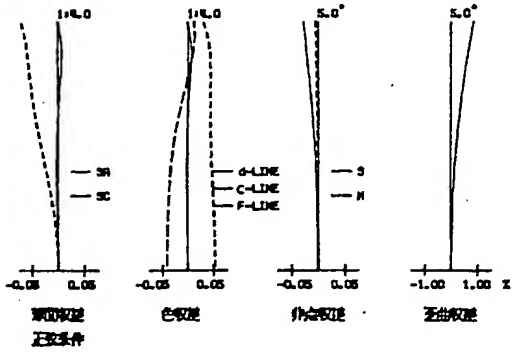
第 8 図



第 9 図



第10 図



TELEPHOTO OBJECT LENS

Japanese Unexamined Patent No. Sho-62-96919

Laid-open on: May 6, 1987

Application No. Sho-61-102780

Filed on: May 2, 1986

Inventor: Nobutaka MINEFUJI

Applicant: Asahi Optical Co., Ltd.

Patent Attorney: Tatsuo ITAMI

SPECIFICATION

1. TITLE OF THE INVENTION

Telephoto Object Lens

2. WHAT IS CLAIMED IS;

Telephoto object lens composed of: from the object side, first and second lens groups both having positive power, wherein the first lens group is composed of one positive lens and one negative lens, the second lens group is composed of a positive meniscus lens whose convex surfaces are oriented to the object side and a negative meniscus lens whose convex surfaces are oriented to the object side, and the following respective conditions are satisfied:

(1) $1.0<f_I/f<3.0$

(2) $0.2<d_4/f<0.7$

(3) $0.1<|r_2|/f_I<0.7$

(4) $1.0<r_7/r_8<2.0$

(5) $\nu_{I+}>65, \nu_{I+}-\nu_{I-}>25$

(6) $d_6/f<0.15$

(7) $10<\nu_{II+}-\nu_{II-}<50$

Herein,

f: Focal distance of the entire system

f_I: Focal distance of the first lens group

d_i: Distance between the i^{th} surface and $(i+1)^{th}$ surface from the object side

r_i: Radius of curvature of the i^{th} surface from the object side

ν_{I+}: Abbe's number of the positive lens of the first lens group

ν_{I-}: Abbe's number of the negative lens of the first lens group

ν_{II+}: Abbe's number of the positive lens of the second lens group

ν_{II-}: Abbe's number of the negative lens of the second lens group

3. DETAILED DESCRIPTION OF THE INVENTION

a. Field of the Invention

The present invention relates to a large-aperture telephoto object lens of a simple configuration and having an aperture ratio of around 1:4, which is used for astronomical photography, etc.

b. Prior Arts and Problems thereof

Priorly, as an optical system to be used for astronomical photography, a reflective telephoto lens using a Schmidt optical system, a super-telephoto lens for general photography, a short-focal-length object lens for an astronomical telescope or the like has been used.

Reflective telescope lenses such as Schmidt optical systems can be obtained with a relatively large aperture, however, problems exist such that the aspherization process is difficult, mass-production is difficult, and cost is high, and in addition thereto, adjustment of the optical system is difficult, therefore, a high-quality image cannot be easily obtained.

In addition, sophisticated super-telephoto lenses for general photography employing special low-dispersion glass, which have become common in recent years can be considered for use. These lenses are suitable for astronomical photography but are composed of a great number of lenses, have an internal focusing mechanism and a diaphragm mechanism, and are very expensive.

Accordingly, short-focal-length astronomical telescope object lenses are often used as astronomical photographic lenses. However, priorly, chromatic aberration, spherical aberration, and coma aberration have been required to be sufficiently lowered

in astronomical telescopes, and as disclosed in Japanese Unexamined Patent Publication No. Sho-59-220711, for example, an aperture ratio of around 1:7 is the limit, the lens is slightly dark for use in astronomical photography, and a tracking equatorial telescope is required, therefore, lenses having a larger aperture and a wider angle of view have been demanded.

c. Object

The present invention is made in view of such aspects as in the above and aims to provide a wide-aperture, wide-angle of view telephoto object lens which is composed of a small number of component lenses and is low in cost despite a large aperture.

d. Construction of the Invention

In order to achieve the aforementioned object, a telephoto object lens according to the present invention is composed of: from the object side, first and second lens groups both having positive power, wherein

the first lens group is composed of one positive lens and one negative lens, the second lens group is composed of a positive meniscus lens whose convex surfaces are oriented to the object side and a negative meniscus lens whose convex surfaces are oriented to the object side, and furthermore, the following respective conditions are satisfied:

(1) $1.0<f_I/f<3.0$

(2) $0.2<d_4/f<0.7$

(3) $0.1<|r_2|/f_I<0.7$

(4) $1.0<r_7/r_8<2.0$

(5) $\nu_{I+}>65, \nu_{I+}-\nu_{I-}>25$

(6) $d_6/f<0.15$

(7) $10<\nu_{II+}-\nu_{II-}<50$

Herein,

f: Focal distance of the entire system

f_I: Focal distance of the first lens group

d_i: Distance between the i^{th} surface and $(i+1)^{th}$ surface from the object side

r_i: Radius of curvature of the i^{th} surface from the object side

ν_{I+}: Abbe's number of the positive lens of the first lens group

ν_{I-}: Abbe's number of the negative lens of the first lens group

ν_{II+}: Abbe's number of the positive lens of the second lens group

ν_{II-}: Abbe's number of the negative lens of the second lens group

e. Actions

Now, respective conditions will be described.

Condition (1) concerns a focal distance of the first lens group. If the lower limit of condition (1) is exceeded, power of the first lens group becomes excessively great, the radius of curvature of each surface becomes small, and thus it becomes

difficult to suppress spherical aberration so as to become small. In contrast thereto, if the upper limit is exceeded, a burden on the second lens becomes excessively great and also the telephoto ratio becomes great, thus it becomes difficult to suppress the entire lens length so as to become short, which is not preferable.

Condition (2) concerns an air gap between the first lens group and second lens group. If the lower limit of condition (2) is exceeded and the second lens group approximates the first lens group, it becomes difficult to satisfactorily correct, at the second lens group, a curvature of field which is generated by the first lens group basically of a tablet composition. In addition, the lens diameter of the second lens group becomes great, thus also resulting in a high cost. In contrast thereto, if the upper limit of condition (2) is exceeded, back focus becomes short, thereby causing a problem in an attachment of a camera, etc.

Condition (3) is a condition for satisfactorily correcting spherical aberration and coma aberration in the first lens group. If the lower limit of condition (3) is exceeded, to correct the spherical aberration and coma aberration, it becomes necessary to reduce the radius of curvature of the third surface in line with the second surface, therefore, a high-order

spherical aberration easily occurs. In contrast thereto, if the upper limit is exceeded, correction of the spherical aberration becomes easy, whereas it becomes difficult to suppress secondary spectrum chromatic aberration so as to become small.

Condition (4) concerns a radius of curvature of the negative lens of the second lens group. If the lower limit of condition (4) is exceeded, it becomes difficult to suppress the Petzval sum so as to become small and also an insufficient correction of the curvature of field occurs. In contrast thereto, if the upper limit is exceeded, a negative Petzval sum is increased, which is not preferable.

Condition (5) is a condition for correcting spherical aberration and chromatic aberration in a balanced manner. By maintaining Abbe's number of the positive lens of the first group at 65 or more according to condition (5), it becomes possible to suppress secondary spectrum chromatic aberration, which occurs in the first lens group, so as to become small. Furthermore, by maintaining the difference in Abbe's number between the positive lens and negative lens of the first lens group at 25 or more, it becomes possible to disperse the power of each lens to satisfy conditions for chromatic aberration and thus to suppress a high-order spherical aberration from

occurring.

Condition (6) concerns an air gap between the positive lens and negative lens of the second lens group. If the upper limit of condition (6) is exceeded, it becomes possible to disperse the power of the first lens group to suppress a high-order spherical aberration from occurring, whereas, it becomes difficult to correct a curvature of field without greatly changing, at the second lens group, the chromatic aberration that has been satisfactorily corrected at the first lens group.

Condition (7) is a condition for decreasing a chromatic aberration which occurs in the second lens group. The present invention is characterized in that secondary spectrum chromatic aberration is mainly suppressed so as to become small in the first lens group, however, by maintaining the difference in Abbe's number between the positive lens and negative lens of the second lens group at 10-50, it becomes possible to correct the spherical aberration and curvature of field without greatly changing the chromatic aberration that has been satisfactorily corrected at the first lens group.

f. Embodiment

Hereinafter, numeric value data of embodiments of the present invention will be shown.

Herein, f represents a focal distance, F_{NO} represents an

aperture ratio, ω represents a half angle of view, r represents a radius of curvature of each lens surface, d represents a gap between the i^{th} surface and $(i+1)^{th}$ surface, n represents a refractive index at the d-line of each lens, and ν represents Abbe's number of each lens.

[Embodiment 1]

$f=100.0$ $F_{NO}=1:4.0$ $\omega=5.0°$

Surface No.	r	d	n	ν
1	51.005	1.750	1.61340	43.8
2	26.700	0.300		
3	26.694	4.500	1.49700	81.6
4	475.283	43.089		
5	22.296	2.250	1.58913	61.0
6	50.458	2.705		
7	23.941	5.500	1.72342	37.9
8	13.899			

$f_I=1.48f$ $d_4=0.43f$

$|r_2|=0\downarrow 18f_I$ $r_7/r_8=1.72$

$\nu_{I+}=81.6$ $\nu_{I+}-\nu_{r-}=37.8$

$d_6=0.03f$ $\nu_{II+}-\nu_{II-}=23.1$

[Embodiment 2]

$f=100.0$ $F_{NO}=1:4.0$ $\omega=5.0°$

Surface No.	r	d	n	ν
1	51.264	4.501	1.49700	81.6
2	-51.264	0.755		
3	-49.799	1.750	1.58144	40.8
4	-2125.590	37.285		
5	24.232	2.251	1.56883	56.3
6	35.434	3.333		
7	20.466	5.502	1.62004	36.3
8	13.856			

$f_I=1.22f$ $d_4=0.37f$

$|r_2|=0.42f_I$ $r_7/r_8=1.48$

$\nu_{I+}=81.6$ $\nu_{I+}-\nu_{r-}=40.8$

$d_6=0.03f$ $\nu_{II+}-\nu_{II-}=20.0$

[Embodiment 3]

$f=100.0$ $F_{NO}=1:4.0$ $\omega=5.0°$

Surface No.	r	d	n	ν
1	76.453	3.750	1.48749	70.1
2	-93.796	1.250		
3	-89.967	1.750	1.80518	25.4
4	-267.477	38.808		
5	29.009	2.250	1.65160	58.5
6	53.458	10.982		

7	19.938	5.000	1.80518	25.4
8	14.046			

f_I=1.75f d_4=0.39f

$|r_2|$=0.54f_I r_7/r_8=1.42

ν_{I+}=70.1 $\nu_{I+}-\nu_{r-}$=44.7

d_6=0.11f $\nu_{II+}-\nu_{II-}$=33.1

[Embodiment 4]

f=100.0 F_{NO}=1:4.0 ω=5.0°

Surface No.	r	d	n	ν
1	57.456	4.800	1.49700	81.6
2	-44.211	0.961		
3	-41.983	2.000	1.52944	51.7
4	142.685	32.498		
5	24.973	2.776	1.49700	81.6
6	78.233	1.073		
7	21.148	6.000	1.74950	35.3
8	14.298			

f_I=2.47f d_4=0.32f

$|r_2|$=0.18f_I r_7/r_8=1.48

ν_{I+}=81.6 $\nu_{I+}-\nu_{r-}$=29.9

d_6=0.011f $\nu_{II+}-\nu_{II-}$=46.3

[Embodiment 5]

$f=100.0$ $F_{NO}=1:4.0$ $\omega=5.0°$

Surface No.	r	d	n	ν
1	54.309	4.800	1.49700	81.6
2	-36.414	0.441		
3	-35.414	2.000	1.54072	47.2
4	1106.305	29.999		
5	17.775	2.325	1.70154	41.2
6	28.457	0.250		
7	20.510	3.750	1.71736	29.5
8	12.621			

$f_I=1.35f$ $d_4=0.30f$

$|r_2|=0.27f_I$ $r_7/r_8=1.63$

$\nu_{I+}=81.6$ $\nu_{I+}-\nu_{I-}=34.4$

$d_6=0.003f$ $\nu_{II+}-\nu_{II-}=11.7$

g. Effects of the Invention

As has been described above, a telephoto object lens of the present invention has a lens composition of positive, negative, positive, and negative, or negative, positive, positive, and negative, and satisfies the above-described conditions. Thereby, as can be understood from a comparison between the aberration diagrams disclosed in Japanese Unexamined Patent

Publication No. Sho-59-220711 and aberration diagrams of Embodiments 1, 2, 3, 4, and 5 of the present invention, in contrast to the invention of Japanese Unexamined Patent Publication No. Sho-59-220711 showing an aperture ratio of 1: 6.7 and a half angle of view of 2.5°, a large-aperture diameter, wide-angle of view telephoto object lens which is composed of a small number of lenses, 4 lenses, is low in cost and whose aberrations are sufficiently small can be obtained in the present invention despite achievement of a large aperture diameter and a wide angle of view, such as an aperture ratio of 1:4 and a half angle of view of 5°.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a lens sectional diagram of Embodiment 1 of the present invention, Fig. 2 is a various aberrations diagram of Embodiment 1 of the present invention, Fig. 3 is a lens sectional diagram of Embodiment 2 of the present invention, Fig. 4 is a various aberrations diagram of Embodiment 2 of the present invention, Fig. 5 is a lens sectional diagram of Embodiment 3 of the present invention, Fig. 6 is a various aberrations diagram of Embodiment 3 of the present invention, Fig. 7 is a lens sectional diagram of Embodiment 4 of the present invention, Fig. 8 is a various aberrations diagram of Embodiment 4 of the

present invention, Fig. 9 is a lens sectional diagram of Embodiment 5 of the present invention, and Fig. 10 is a various aberrations diagram of Embodiment 5 of the present invention.

Fig.1

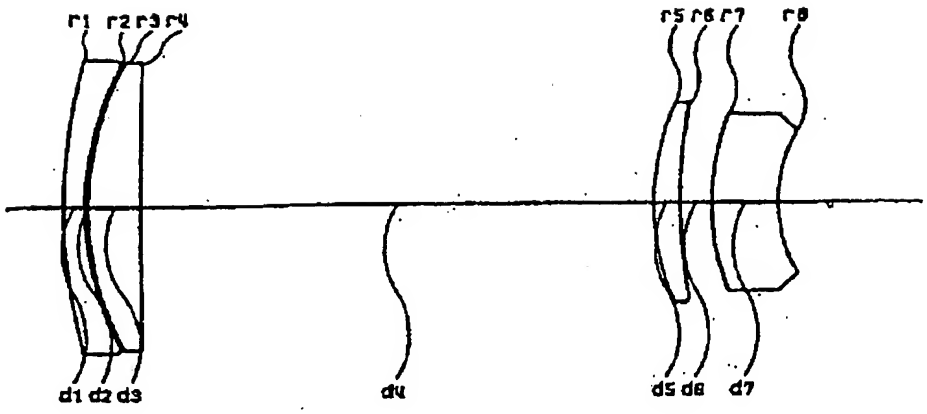
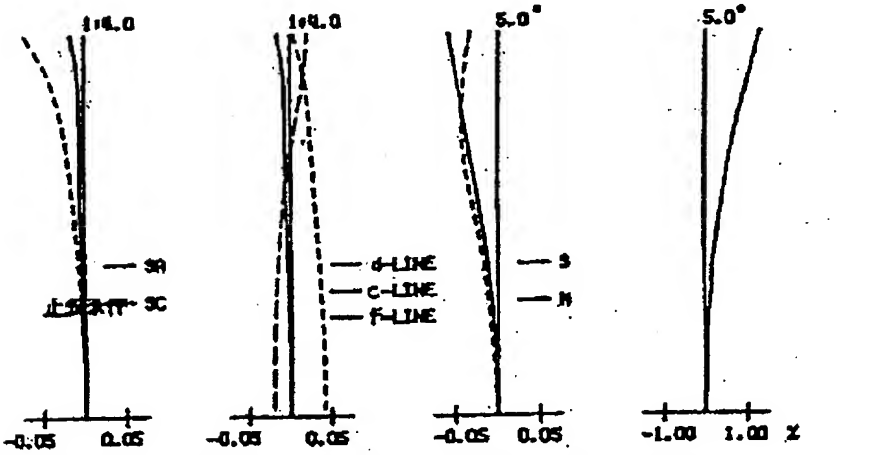


Fig.2



Spherical aberration Chromatic aberration Astigmatism Distortion aberration

Sine condition

Fig.3

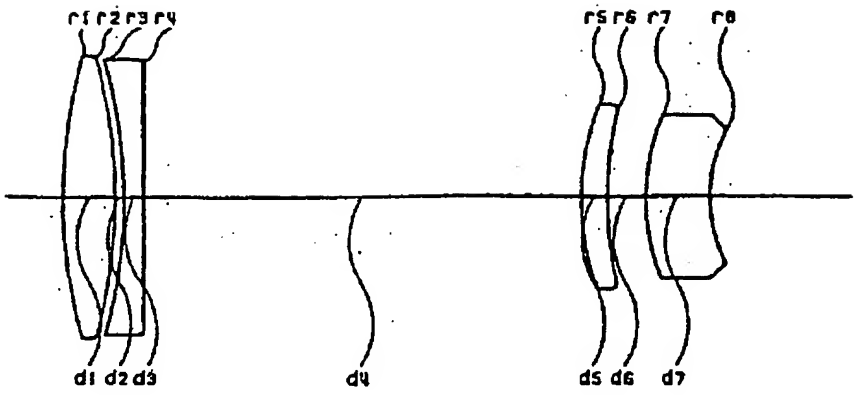

r1 r2 r3 r4
r5 r6 r7 r8
d1 d2 d3
d4
d5 d6 d7

Fig.4

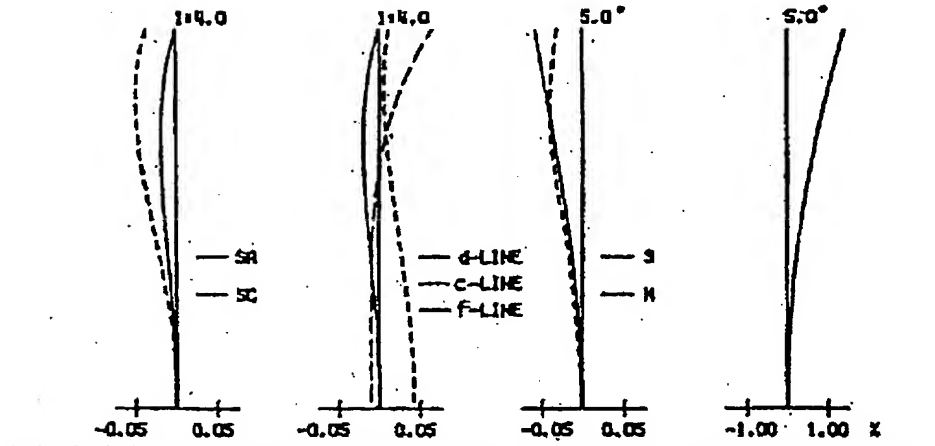

f=4.0
SA
SC
-0.05
0.05
Spherical aberration
Sine condition
f=4.0
d-LINE
c-LINE
F-LINE
-0.05
0.05
Chromatic aberration
5.0°
S
M
-0.05
0.05
Astigmatism
5.0°
-1.00
1.00
%
Distortion aberration

Fig.5

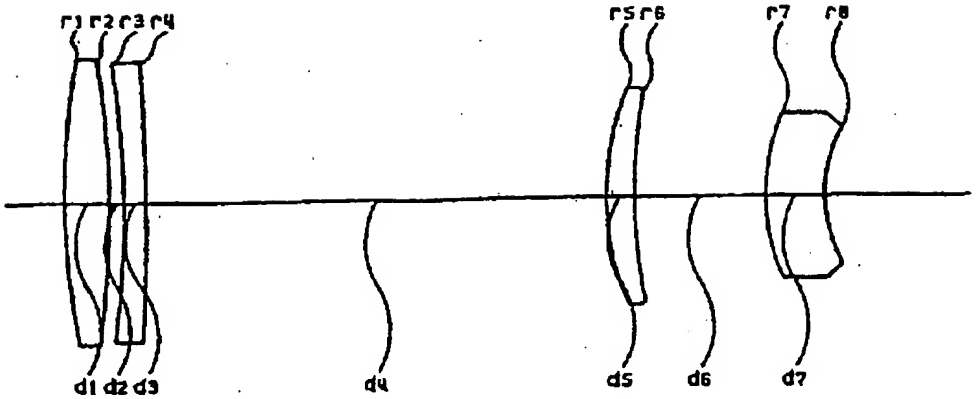
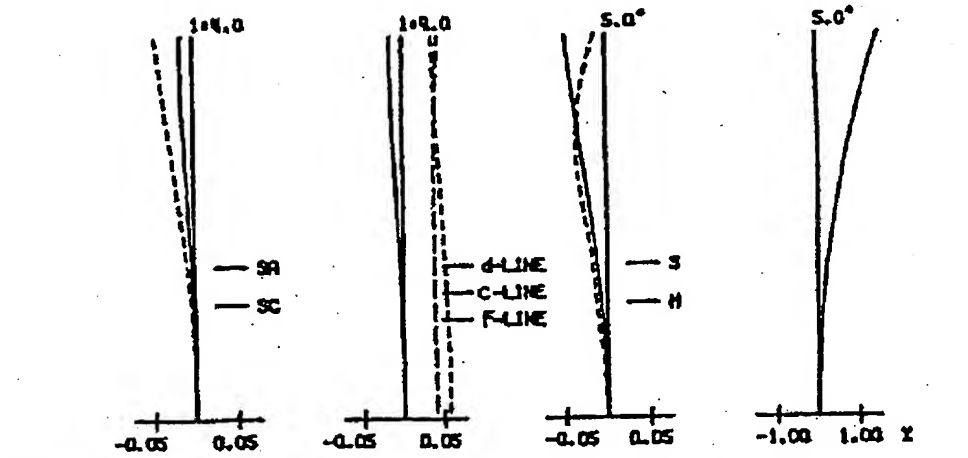


Fig.6



Spherical aberration
Sine condition

Chromatic aberration

Astigmatism

Distortion aberration

Fig.7

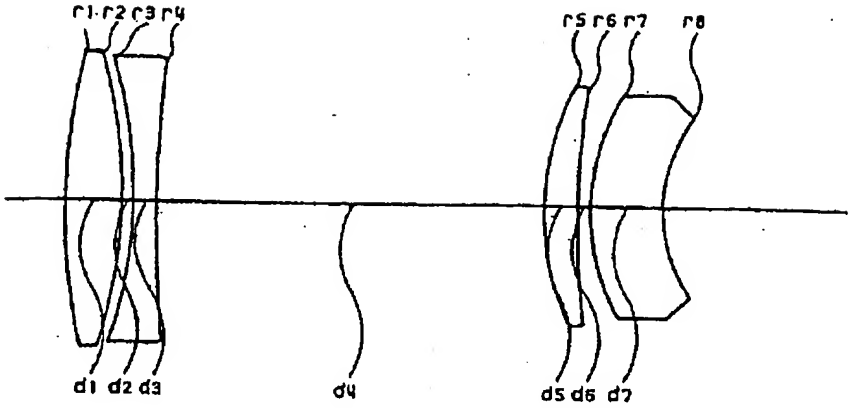
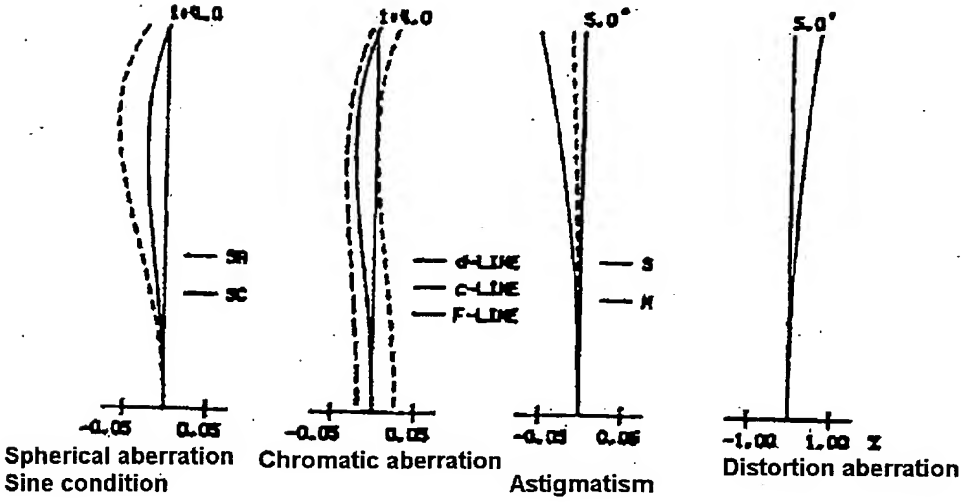


Fig.8



Spherical aberration
Sine condition

Chromatic aberration

Astigmatism

Distortion aberration

Fig.9

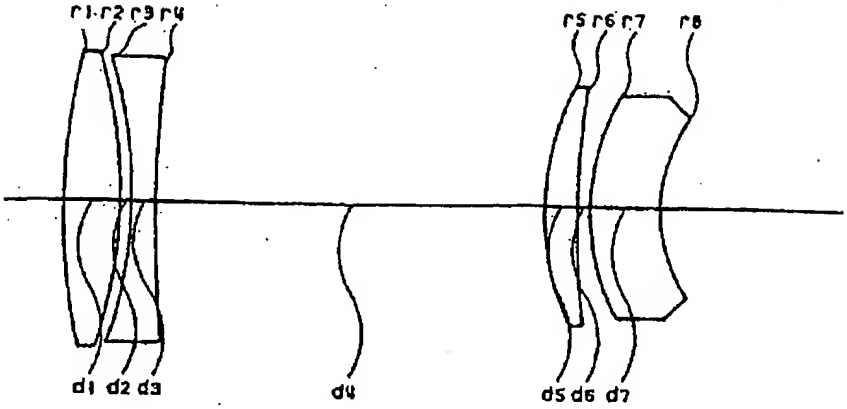
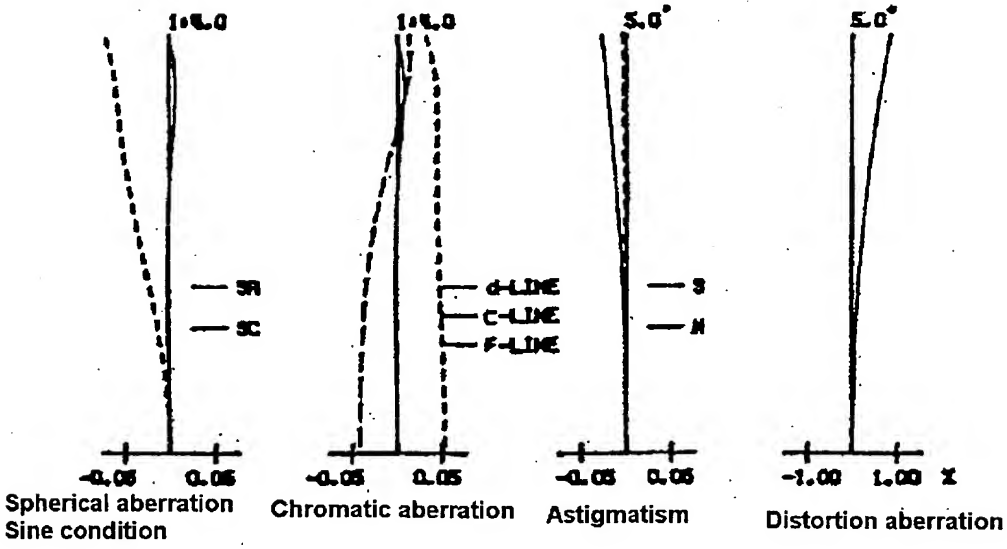

r1 r2 r3 r4
r5 r6 r7 r8
d1 d2 d3
d4
d5 d6 d7

Fig.10


SR
SC
d-LINE
C-LINE
F-LINE
S
M
-0.05
0.05
-1.00
1.00
X
Spherical aberration
Sine condition
Chromatic aberration
Astigmatism
Distortion aberration